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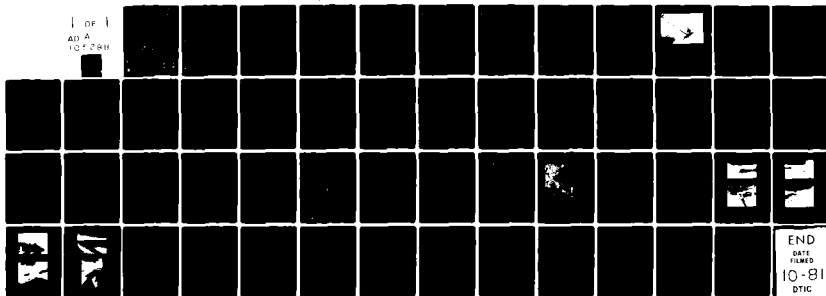
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NATIONAL DAM SAFETY PROGRAM. RUSSELL ELSEY DAM (MO 30102), MISS--ETC(U)
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AD A105288

**RUSSELL ELSEY DAM
WASHINGTON COUNTY, MISSOURI
MO 30102**

**PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY INSPECTION**



**United States Army
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St. Louis District

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.		

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210 TUCKER BOULEVARD, NORTH
ST. LOUIS, MISSOURI 63101

REPLY TO
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LMSD-PD

SUBJECT: Russell Elsey Dam (MO 30102) Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Russell Elsey Dam, Washington County, Missouri, MO 30102.

It was prepared under the National Program of Inspection of Non-Federal Dams.

This dam has been classified as unsafe, emergency by the St. Louis District as a result of the application of the following criteria:

- The combined spillway capacity will not pass a 10-year frequency flood without overtopping of the dam. The spillways are, therefore, considered to be unusually small and seriously inadequate.
- Overtopping of the dam could result in failure.
- Dam failure significantly increases the hazard to life and property downstream.

SUBMITTED BY:

SIGNED

Chief, Engineering Division

2 DEC 1980

Date

APPROVED BY:

SIGNED

Colonel, CE, District Engineer

2 DEC 1980

Date

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RUSSELL ELSEY DAM
Washington County, Missouri
Missouri Inventory No. 30102

Phase I Inspection Report
National Dam Safety Program

Prepared by

Woodward-Clyde Consultants
Chicago, Illinois

Under Direction of
St Louis District, Corps of Engineers

for
Governor of Missouri
September 1980

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam	Russell Elsey Dam
State Located	Missouri
County Located	Washington
Stream	North Fork, Fourche a Renault
Date of Inspection	23 June 1980

Russell Elsey Dam, Missouri Inventory Number 30102, was inspected by L. M. Krazynski (geotechnical engineer), R. Juyal (hydrologist) and J.B. Stevens (geotechnical engineer).

The dam inspection was made following the guidelines presented in the "Recommended Guidelines for Safety Inspection of Dams". These guidelines were developed by the Chief of Engineers, U.S. Army, Washington, D.C., with the help of federal and state agencies, professional engineering organizations, and private engineers. The resulting guidelines represent a consensus of the engineering profession. They are intended to provide an expeditious identification, based on available data and a visual inspection, of those dams which may pose hazards to human life or property. In view of the limited nature of the study, no assurance can be given that all deficiencies have been identified.

The St Louis District, Corps of Engineers has classified this dam a high hazard dam; we concur with this classification. The estimated hazard zone extends approximately three miles downstream. There are at least nine occupied structures, State Rte 8, and a medium duty road located in this zone.

The dam is classified small size due to its 312 ac-ft storage volume. Its height is 21 ft. The classification for a small size dam is based on a height between 25 and 40 ft or a storage capacity between 50 and 1000 ac-ft.

Our evaluation indicates the dam is in generally poor condition. Hydrologic/hydraulic analyses indicate that the spillway will not pass the 10 percent probability-of-occurrence (10-yr flood) event without overtopping the dam. These analyses also indicate the dam will be overtopped for a hydrologic event which produces greater than 11 percent of the Probable Maximum Flood (PMF). The PMF is defined as the flood event that may be expected to occur from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. There is substantial erosion just downstream of the main and auxiliary spillways. Also, seepage and stability analyses comparable to the recommended guideline requirements are not available.

The recommended spillway design flood is 100 percent of the PMF. This recommendation is based upon the number and proximity of the downstream residences (nine occupied structures in the first 1.7 mi of the hazard zone), and the high outflow due to the relatively large drainage basin for this small-sized dam. Additional studies, discussed in Section 7.2b, which are beyond the scope of this investigation may indicate that a smaller spillway design flood can be justified.

The following remedial measures and additional studies are recommended for the Russell Elsey Dam:

1. Design and construction of a spillway with adequate capacity and/or raising the dam crest elevation to provide adequate flood storage capacity to be able to pass the PMF without endangering downstream residents or property. The eroded areas downstream of the existing spillways should be included in this reconstruction program.
2. Implementation of a program of periodic inspections and maintenance for the dam and appurtenant structures. The program should include but not be limited to the monitoring of seepage in the auxiliary spillway and maintaining the dam slopes and discharge channels free of trees and flow obstructions. Records of the inspections and maintenance should be kept.
3. Conduct static and seismic stability analyses and a seepage analysis in accordance with the "Recommended Guidelines for Safety Inspection of Dams".

It is recommended that the design of the dam and/or spillways to pass the PMF should be done immediately. The seepage and stability analyses and the implementation of an inspection and maintenance program should be done without undue delay. All remedial measures and studies should be done under the guidance of an engineer experienced in the design and construction of earth dams.

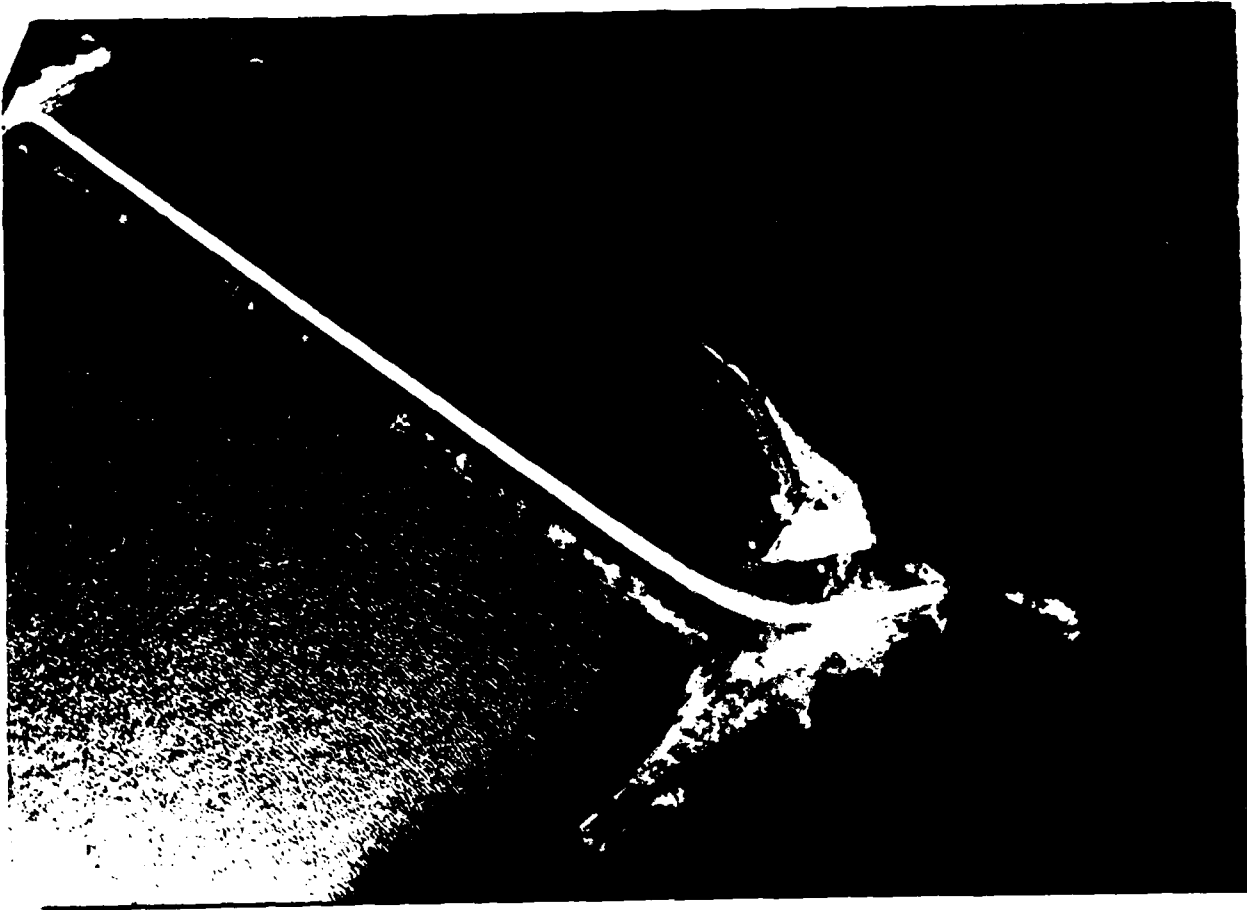
WOODWARD-CLYDE CONSULTANTS



Richard G. Berggreen
Registered Geologist



Leonard M. Krazynski, P.E.
Vice President



OVERVIEW

RUSSELL ELSEY DAM

MISSOURI INVENTORY NO. 30102

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
RUSSELL ELSEY DAM, MISSOURI INVENTORY No. 30102
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2.	Drainage Basin and Site Topography
3.	Plan and Sections of Dam
4.	Regional Geologic Map

APPENDICES

A	Fig A-1: Photo Location Sketch
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Photographs

1. View of upstream slope looking east. Note gravel wave protection. Entrance to low flow outlet at left.
2. Exit for low flow outlet and concrete lined channel.
3. View of downstream slope looking west. Note thick grass and brush cover.
4. View of valve box for low level outlet at toe of dam. Outlet inoperable.
5. Lip of main spillway and head of discharge channel.
6. Discharge channel looking downstream. Note spillway is on rock/soil contact and erosion has taken place under concrete.
7. Upstream view of auxiliary spillway showing deterioration of concrete and erosion along edge. Note seepage at center.
8. Discharge channel for auxiliary spillway looking downstream. Note seepage.

B	Hydraulic/Hydrologic Data and Analyses
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**PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
RUSSELL ELSEY DAM, MISSOURI INVENTORY No. 30102**

**SECTION I
PROJECT INFORMATION**

I.1 General

- a. **Authority.** The National Dam Inspection Act, Public Law 92-367, provides for a national inventory and inspection of dams throughout the United States. Pursuant to the above, an inspection was conducted of the Russell Elsey Dam, Missouri Inventory Number 30102.
- b. **Purpose of investigation.** "The primary purpose of the Phase I investigation program is to identify expeditiously those dams which may pose hazards to human life or property. The Phase I investigation will develop an assessment of the general condition with respect to safety of the project based upon available data and a visual inspection, determine any need for emergency measures, and conclude if additional studies, investigations and analyses are necessary and warranted" (Chapter 3, Recommended Guidelines for Safety Inspection of Dams).
- c. **Evaluation criteria.** The criteria used to evaluate the dam were established in the "Recommended Guidelines for Safety Inspection of Dams", Engineering Regulation No. 1110-2-106 and Engineering Circular No. 1110-2-188, "Engineering and Design National Program for Inspection of Non-Federal Dams", prepared by the Office of Chief of Engineers, Department of the Army, and "Hydrologic/Hydraulic Standards, Phase I Safety Inspection of Non-Federal Dams", prepared by the St Louis District, Corps of Engineers (SLD). These guidelines were developed with the help of several federal agencies and many state agencies, professional engineering organizations, and private engineers.

1.2 Description of Project

- a. Description of dam and appurtenances. Russell Elsey Dam is an earth dam constructed for recreational purposes. The dam is approximately 800 ft long and 21 ft high. The main spillway is ungated and located at the west end of the dam (left abutment). An auxiliary spillway, also ungated, is located on the east end (right abutment). The normal pool elevation is controlled by two overflow pipes near the main spillway. There is also what appears to be a low level outlet for reducing the pool elevation. The operability of the low level outlet is unknown.
- b. Location. The dam is on the North Fork of Fourche a Renault, about 4.9 mi SW of Potosi, Washington County, Missouri. It is located in Sec 30, T37N, R2E, on USGS Potosi and Belgrade 7.5 minute quadrangle maps.
- c. Size classification. The dam is classified as small due to its 312 ac-ft storage volume. Its height is 21 ft. The classification for a small size dam is based on a height between 25 and 40 ft or a storage capacity between 50 and 1000 ac-ft.
- d. Hazard classification. The St Louis District, Corps of Engineers (SLD) has classified this dam high hazard potential; we concur with this classification. The SLD estimated hazard zone extends approximately three miles downstream. Located in this zone are at least nine occupied structures, State Rte 8, and a medium duty road.
- e. Ownership. We understand that Mr Russell J. Elsey, 101 Maple St., Potosi, Missouri 63664, is the dam owner. Correspondence should be addressed to him at Elsey Motor Co, P. O. Box 176, 214 E. High St., Potosi, Missouri 63664.
- f. Purpose of dam. The impoundment is used for recreational purposes.
- g. Design and construction history. According to the owner, the dam was constructed in general accordance with guidelines published by the Missouri Conservation Commission. No specific design was prepared for this dam. We understand that the spillways were not designed by a professional engineer.

The dam was constructed in 1966 or 1967 reportedly using soil obtained from the sideslopes of the reservoir.

- h. Normal operating procedures. No operating records were found. Flood flows pass uncontrolled over the spillways. Normal pool elevation is controlled by two overflow pipes near the main spillway (See Photo 2).

1.3 Pertinent Data

- a. Drainage area. Approximately 2.5 mi²
- b. Discharge at damsite.
- | | |
|---|---------------------------|
| Maximum known flood at damsite | Unknown |
| Warm water outlet at pool elevation | Not Applicable (N/A) |
| Diversion tunnel low pool outlet at pool elevation | N/A |
| Diversion tunnel outlet at pool elevation | N/A |
| Gated spillway capacity at pool elevation | N/A |
| Gated spillway capacity at maximum pool elevation | N/A |
| Ungated spillway capacity at maximum pool elevation | 1000 ft ³ /sec |
| Total spillway capacity at maximum pool elevation | 1000 ft ³ /sec |
- c. Elevation (ft above MSL).
- | | |
|---|------------------|
| Top of dam | 1036.9 to 1038.5 |
| Maximum pool-design surcharge | N/A |
| Full flood control pool | N/A |
| Recreation pool | 1033.7 |
| Spillway crest (gated) | N/A |
| Upstream portal invert diversion tunnel | N/A |

Downstream portal invert diversion tunnel	N/A
Streambed at centerline of dam	Unknown
Maximum tailwater	N/A
Toe of dam at maximum section	1017.5

d. Reservoir.

Length of maximum pool	Approximately 1100 ft
Length of recreation pool	Approximately 1000 ft
Length of flood control pool	N/A

e. Storage (acre-feet).

Recreation pool	224
Flood control pool	N/A
Design surcharge	N/A
Top of dam	312

f. Reservoir Surface (acres).

Top of dam	30
Maximum pool	30
Flood control pool	N/A
Recreation pool	25
Spillway crest	25

g. Dam.

Type	Uncontrolled, compacted earth
Length	800 ft
Height	21 ft
Top width	19 ft

Side slopes	Downstream 1.5(H) to 1(V) Upstream unknown (appears to be approx. 3(H) to 1(V) or flatter near the crest)
Zoning	Unknown (probably none)
Impervious core	Unknown (probably homogeneous gravelly clay (CH))
Cutoff	Reported to be 8 ft wide and approx. 6 ft deep to shallow bedrock
Grout curtain	Unknown (probably none)

h. Diversion and regulating tunnel.

Type	None
Length	N/A
Closure	N/A
Access	N/A
Regulating Facilities	N/A

i. Spillway.

	<u>Main</u>	<u>Auxiliary</u>
Type	Trapezoidal, broad-crested, concrete weir	Trapezoidal, broad-crested concrete weir
Length of weir	36 ft (effective length)	60 ft (effective length)
Crest elevation	1033.7	1034.8
Gates	None	None
Upstream channel	Earth, sparse grass, gravel-lined	Earth, sparse grass, gravel-lined
Downstream channel	Earth, sparse grass	Earth, sparse grass

j. Regulating outlets.

- (1) One 12-in. and one 14-in. diameter pipe for regulating normal pool elevation.
- (2) 6-in. diameter pipe for low level outlet. Considered inoperative.

SECTION 2 ENGINEERING DATA

2.1 Design

No design drawings or reports have been found for this dam.

2.2 Construction

No construction records have been located for this dam. The dam was reportedly constructed in 1966 or 1967 from the residual clay soil found on the reservoir valley side slopes.

2.3 Operation

No records were found concerning maintaining a maximum or minimum pool elevation. No records were found documenting the operation of the valve and drain at the toe of the dam nor was it reliably determined that the drain is in fact an operating low level outlet for the lake.

There are no records of outflow at the spillway or of the pool elevation.

2.4 Evaluation

- a. Availability. No data was available for review.
- b. Adequacy. Insufficient data was available to determine the adequacy of the design. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.
- c. Validity. Not applicable.

2.5 Project Geology

The dam site is located on the northern flank of the Ozark structural dome. The bedrock in the area is mapped as Ordovician age Gasconade Formation on the geologic Map of Missouri (Fig 4). The Gasconade Formation is predominantly a cherty dolomite which varies from coarsely crystalline and very cherty at the top to finely crystalline with relatively small amounts of chert near the bottom of the formation. Caves and springs are common in this formation in the central Ozarks, but the field inspection did not identify any evidence of solution activity in the vicinity of the dam.

The soil at the dam site is a gravelly, plastic residual clay (CH) developed on the Gasconade Formation. This soil is apparently the clay used to construct the dam embankment. The site area is mapped on the Missouri General Soils Map as Captina-Clarksville-Doniphan Association.

Three faults or fault zones are mapped within 5 mi of the dam (Fig 4). The Shirley Fault Zone is mapped as approximately 8 mi in length, terminating 2 mi north-northwest of the dam. This fault is mapped as northeast side up. The Palmer Fault Zone, a complex network of short and long faults approximately 34 mi long is located approximately 4 mi south of the dam. The fault is mapped as north side down. The Aptus Fault is located approximately 4-1/2 mi northeast of the dam. This fault has a mapped length of approximately 15 mi and is mapped as northeast side up.

All of the faults in the vicinity of the dam are within Paleozoic age formations. There was no evidence of recent activity found and the area is not considered seismically active. The faults are likely Paleozoic in age and are not considered to pose an unusually severe seismic hazard to the dam.

SECTION 3 VISUAL INSPECTION

3.1 Findings

- a. General. A visual inspection was made of Russell Elsey Dam on 23 June 1980 without an owner's representative present. The dam is an earth dam and is presumed to have a homogeneous section.
- b. Dam. The dam was constructed with a gravelly, dark red, plastic clay (CH) obtained from the reservoir area. The gravel is an angular chert ranging in size from coarse sand to cobbles.

The downstream slope and crest of the dam have a thick grass cover with scattered small bushes except in the roadway. Scattered brush does not appear to represent a hazard to the safety of the dam. Wave protection on the upstream slope consists of coarse gravel. This gravel provides adequate erosion protection for the fetch of this reservoir.

The downstream slope of the dam appears quite steep, approximately 1.5(H) to 1(V). No evidence of slumping, slides or other indications of unstable slopes were noted during the visual inspection.

The vertical and horizontal alignment of the dam appear undisturbed. There is no evidence of sinkhole development, detrimental settlement, depressions, cracking or animal burrows on the dam. No evidence of overtopping was noted. Erosion of soil beneath and alongside the spillway concrete lining was observed.

Seepage of approximately 1 to 2 gal/min was noted exiting from beneath the concrete of the auxiliary spillway (Photo 7).

- c. Appurtenant structures.

1. Main spillway. The main spillway is a trapezoidal channel lined with concrete. It is approximately 36 ft long and 3 ft high. The concrete lining is

reinforced with welded wire fabric (WWF) and typically 3 in. thick. It was placed by dumping and screeding. There are no construction joints. In several locations there are holes in the concrete through which water has passed and eroded the underlying soil to rock. Voids as large as 4-ft deep were observed. As the spillway is founded on rock, failure of the concrete is not considered a significant safety hazard.

2. Auxiliary spillway. The auxiliary spillway is a trapezoidal channel lined with concrete. It is approximately 60 ft wide. The concrete is typically 3 in. thick and reinforced with WWF. A portion of the concrete in the center has been eroded away and soil removed by erosion along one edge (Photo 7). Seepage was noted as described in Section 3.1b.. Backward erosion resulting from the concrete failure may cause lowering of the auxiliary spillway and/or breach of the embankment during very heavy flow at the east end of the dam.

3. Low level outlet. The low level outlet at the toe of dam consists of a 4-in. dia iron pipe with a protected valve. The valve has not been maintained nor was it tried by the inspection team for fear of malfunction or breakage. It was not reliably determined that it is an operable low level outlet.

4. Overflow outlets. Two pipes (one 12-in. and one 14-in. diameter) near the main spillway inlet serve to regulate the normal pool elevation during periods of moderate inflow. A crude trash rack protects the inlet. The pipes and the concrete-lined discharge channel appeared to be in good condition.

- d. Reservoir. The reservoir is used for recreational purposes. There are two houses on the slopes surrounding the reservoir. These slopes are wooded, generally flatter than 4(H) to 1(V), and show no signs of instability.
- e. Downstream channel. There is a discharge channel downstream of each of the two spillways. These channels are confluent with the natural stream channel about 150 ft beyond the toe of the dam. There are large trees and brush growing in and along these downstream channels. These trees can obstruct flow in the channels but it is felt that the obstructed flow will not endanger the toe of the dam. The soils in the channels downstream of the spillways are moderately erodible, and are expected to be eroded significantly when exposed

to high flow velocities. It is felt, however, that this erosion will not increase the hazard to the dam. There are no man-made features directly in the downstream channels or the natural stream channel within 1.5 mi of the dam.

3.2 Evaluation

The results of our visual inspection indicate the dam embankment is in generally fair condition. The downstream face appears quite steep, approximately 1.5(H) to 1(V), which is steeper than most other earth dams in the area (typically 2(H) to 1(V) or flatter).

Erosion was noted in the discharge channels below the spillways and has undermined the concrete aprons below both the main and auxiliary spillways. Continued erosion could cause failure and loss of the concrete apron and spillway lining.

Our visual inspection did not find any sinkhole development, detrimental settlement, slides, cracking or any other evidence of instability. The amount of seepage observed was small, but a monitoring program should be implemented to detect any changes in the amount or turbidity of flow. Although backward erosion from the auxiliary spillway may cause a breach at the east end of the dam, it is believed that the only result would be widening and/or deepening of the spillway.

SECTION 4 OPERATIONAL PROCEDURES

4.1 Procedures

So far as could be determined there are no written operational procedures for this dam. The water level is controlled by the spillways, the overflow outlets and the low level outlet.

4.2 Maintenance of the Dam

No records of maintenance on this facility were available.

4.3 Maintenance of Operating Facilities

The iron pipe and valve, assumed to be a low level outlet from the lake, appeared to be inoperative at the time of the inspection. No records were available on maintenance or operation of this outlet.

4.4 Description of Any Warning System in Effect

The inspection did not identify any warning system in effect at this facility.

4.5 Evaluation

There are apparently no formal maintenance or operational procedures in effect. The lack of regular maintenance and periodic inspection is considered a deficiency.

SECTION 5 HYDRAULIC/HYDROLOGIC

5.1 Evaluation of Features

- a. Design data. No hydrologic or hydraulic information was available for evaluation of the dam. Pertinent dimensions of the dam and reservoir were surveyed on 23 June 1980, measured during the field inspection or estimated from topographic mapping. The maps used in the analysis were the USGS Belgrade and Potosi 7.5-minute quadrangle maps.
- b. Experience data. No recorded rainfall, runoff, discharge, pool stage data or overtopping history were available for this reservoir or watershed.
- c. Visual observations. Unlined portions of the facility, such as the approach to the concrete spillway and the discharge channel, will be likely to experience high water velocities during major precipitation events. The velocities expected could cause substantial erosion in the channel prior to overtopping of the dam. If erosion takes place, it will widen the discharge channel and enlarge the spillway. If substantial erosion were to occur at either end of the dam in the location of the spillways, it would not constitute a total failure of the dam, but it would cause damage to the dam and possibly to downstream structures. It must be recognized that with the existing spillway configurations the conditions regulating outflow will not remain constant during periods of high flow due to erosion.

No conditions were noted which could lead to a reduced spillway capacity during a flood occurrence. Other observations regarding the reservoir, spillway and discharge are given in Section 3.

- d. Overtopping potential. To evaluate the overtopping potential of the dam, the geometry and configuration of the two spillways had to first be evaluated. It was determined from field observations that the shape of the cross section of

the spillways were effectively represented by a rectangle for outflow capacity analysis. The effective length (L) of the main spillway was taken as 36 ft, and the crest was surveyed at el 1033.7. The effective length of the auxiliary spillway was taken as 60 ft, and the crest was surveyed at el 1034.8. Effective overtopping of the dam occurs when the water surface exceeds el 1036.9. This elevation is a point on the dam at the east edge of the approach to the main spillway. The hydraulic/hydrologic analyses indicate that there will be overtopping of the dam for the 10 percent probability-of-occurrence event. This is the principal reason why this dam is considered in poor condition.

Our analyses also indicate that the dam will be overtopped for a event which produces greater than 11 percent of the Probable Maximum Flood (PMF). The PMF is defined as the flood event that may be expected to occur from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The following table presents the expected severity of overtopping for various events:

Percent PMF	Maximum Reservoir W.S. Elev. ft, MSL	Maximum Depth Over Dam, ft	Maximum Outflow, ft ³ /sec	Duration of Overtopping, hrs
11	1036.9	0	1000	0
50	1039.0	2.1	4890	7.3
100	1040.0	3.1	9790	12.7

It should be noted that at 100 percent of the PMF, the depth of water over the dam will reach three feet and the dam will be overtopped for nearly thirteen hours. During this time period, the floodwaters will have substantial potential to erode the earthen dam crest and downstream face in the zone of overtopping. Significant erosion of the crest could cause a breach and failure of the dam.

It is our opinion that the design spillway capacity for this dam should be 100 percent of the PMF, unless the additional studies discussed in Section 7.2b indicate that less than 100 percent of the PMF is justified. This recommendation is based upon the number and proximity of the downstream residences (nine occupied structures in the first 1.7 mi of the hazard zone), and the high outflow due to the relatively large drainage basin for this small-sized dam. The loss of life and property could be large in the event of a dam breach.

SECTION 6

STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

- a. Visual observations. The upstream slope of the Russell Elsey Dam is estimated to be 3(H) to 1(V) or flatter. The downstream slope is 1.5(H) to 1(V). The visual inspection of the dam revealed no evidence of horizontal or vertical displacement of the dam crest alignment. Cracking, detrimental settlement, slides, depressions or other signs of instability were not observed. Erosion of soil beneath and alongside the spillway concrete lining was observed. This results in loss of support and there is a risk of loss of the lining during a severe flood.
- b. Design and construction data. No design or construction data were available for this dam. The relatively steep downstream slopes of 1.5(H) to 1(V) require stability analysis to verify the long-term and seismic stability of the dam.

Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspections of Dams" were not available, which is considered a deficiency.
- c. Operating records. No operating records or water level records are maintained for this facility.
- d. Post construction changes. The lack of drawings or construction reports precludes the identification of post construction changes. However, there were no obvious changes observed.
- e. Seismic stability. The dam is in Seismic Zone 2, to which the guidelines assign a moderate damage potential. In view of the gravelly clay used in the construction of the dam, liquefaction is unlikely during a seismic event. However, since no static stability analysis is available for review, the seismic stability cannot be evaluated.

SECTION 7 ASSESSMENT/REMEDIAL MEASURES

7.1 Dam Assessment

- a. **Safety.** Based on the visual inspection, Russell Elsey Dam is judged as being in a generally poor condition. The major deficiency is the low spillway capacity. The spillways are unable to pass a 10 percent probability-of-occurrence event without overtopping of the dam. The dam will also be overtopped during hydrologic events which produce more than 11 percent of the PMF. Additional deficiencies include substantial erosion downstream of the existing spillways and the lack of seepage and stability analyses.

- b. **Adequacy of information.** The visual inspection provided a reasonable base of information for the conclusions and recommendations presented in this Phase I report.

Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

- c. **Urgency.** The deficiencies described in this report could affect the risk of failure of this dam. Those recommendations that should be implemented immediately to prevent deterioration of the facility are addressed in Section 7.2b.
- d. **Necessity for Phase II.** In accordance with the Recommended Guidelines for Safety Inspection of Dams, the subject investigation was a minimum study. This study revealed that additional in-depth investigations are needed to complete the assessment of the safety of the dam. Those investigations which should be performed immediately are described in Section 7.2b. It is our understanding from discussions with the SLD that any additional investigations are the responsibility of the owner.

7.2 Remedial Measures

- a. **Alternatives.** There are several general options which may be considered to reduce the possibility of dam failure or to diminish the harmful consequences of such a failure. Some of these options are:
1. Remove the dam, or breach it to prevent storage of water.
 2. Increase the height of dam and/or spillway size to pass the probable maximum flood without overtopping the dam.
 3. Purchase downstream land that would be adversely impacted by dam failure and restrict human occupancy.
 4. Enhance the stability of the dam to permit overtopping by the probable maximum flood without failure.
 5. Provide a highly reliable flood warning system (generally does not prevent damage but diminishes chances for loss of life).
- b. **Recommendations.** Based on our inspections of Russell Elsey Dam it is recommended that a detailed study be conducted immediately, the objective of which would be to design and construct a spillway system to safely accomodate the spillway design flood. The recommended spillway design flood is 100 percent of the PMF. This recommendation is based upon the number and proximity of the downstream residences (nine occupied structures in the first 1.7 mi of the hazard zone), and the high outflow due to the relatively large drainage basin for this small-sized dam. The recommended spillway design should investigate in detail, the erosion potential of the dam materials and the potential inundation of the downstream residences during various precipitation events. It may be shown that a design flood of less than 100 percent PMF can be justified. The eroded areas downstream of the existing spillways should be included in the recommended evaluation and design program.

It is also recommended that seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" be performed for this dam without undue delay.

All remedial measures should be performed under the guidance of an engineer experienced in the design and construction of earth dams.

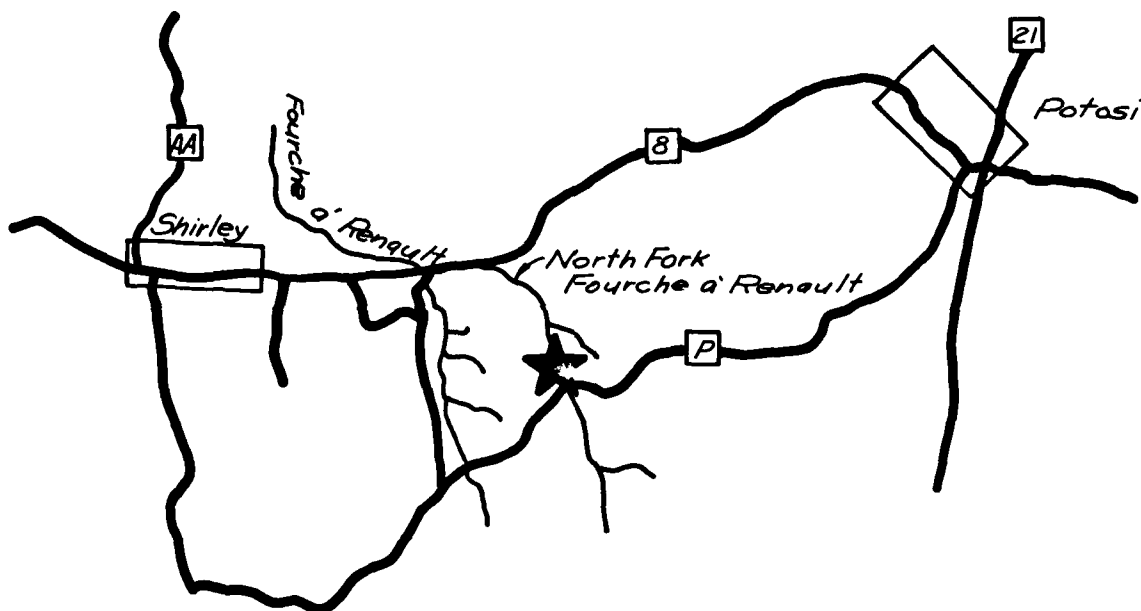
- c. O & M procedures. To provide for adequate maintenance of this facility, it is recommended that a program of periodic inspections be implemented to identify potential deterioration of the facility. The result of this program will be to recommend maintenance requirements. The inspection and maintenance should be performed under the guidance of an engineer experienced in the design and construction of earth dams. Maintenance should include control of vegetation on the dam as well as spillway and discharge channel maintenance. Removal of large trees should be under the guidance of an engineer experienced in the design and construction of earth dams. Indiscriminant clearing could jeopardize the safety of the dam. Records of the inspection and maintenance should be kept.

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- Allgood, Ferris P., and Persinger, Ivan, D., 1979, "Missouri General Soil Map and Soil Association Descriptions," US Department of Agriculture, Soil Conservation Service and Missouri Agricultural Experiment Station.
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- Hydrologic Engineering Center, US Army Corps of Engineers, 1978, "Flood Hydrograph Package (HEC-1) Users Manual for Dam Safety Investigations".
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- St Louis District, US Army Corps of Engineers, 1979, "Hydrologic/Hydraulic Standards, Phase I Safety Inspection of Non-Federal Dams".
- US Department of Commerce, US Weather Bureau, 1956, "Seasonal Variation of the Probable Maximum Precipitation East of the 105th Meridian for Areas from 10 to 1,000 Square Miles and Durations of 6, 12, 24 and 48 Hours," Hydrometeorological Report No. 33.
- US Soil Conservation Service, 1971, "National Engineering Handbook," Section 4, Hydrology, 1971.



Vicinity Map



Scale, miles

Legend

- County Line
- ~ [] ~ State highway and Route No.
- ~ River or Creek
- [] City or Town
- ★ Project location

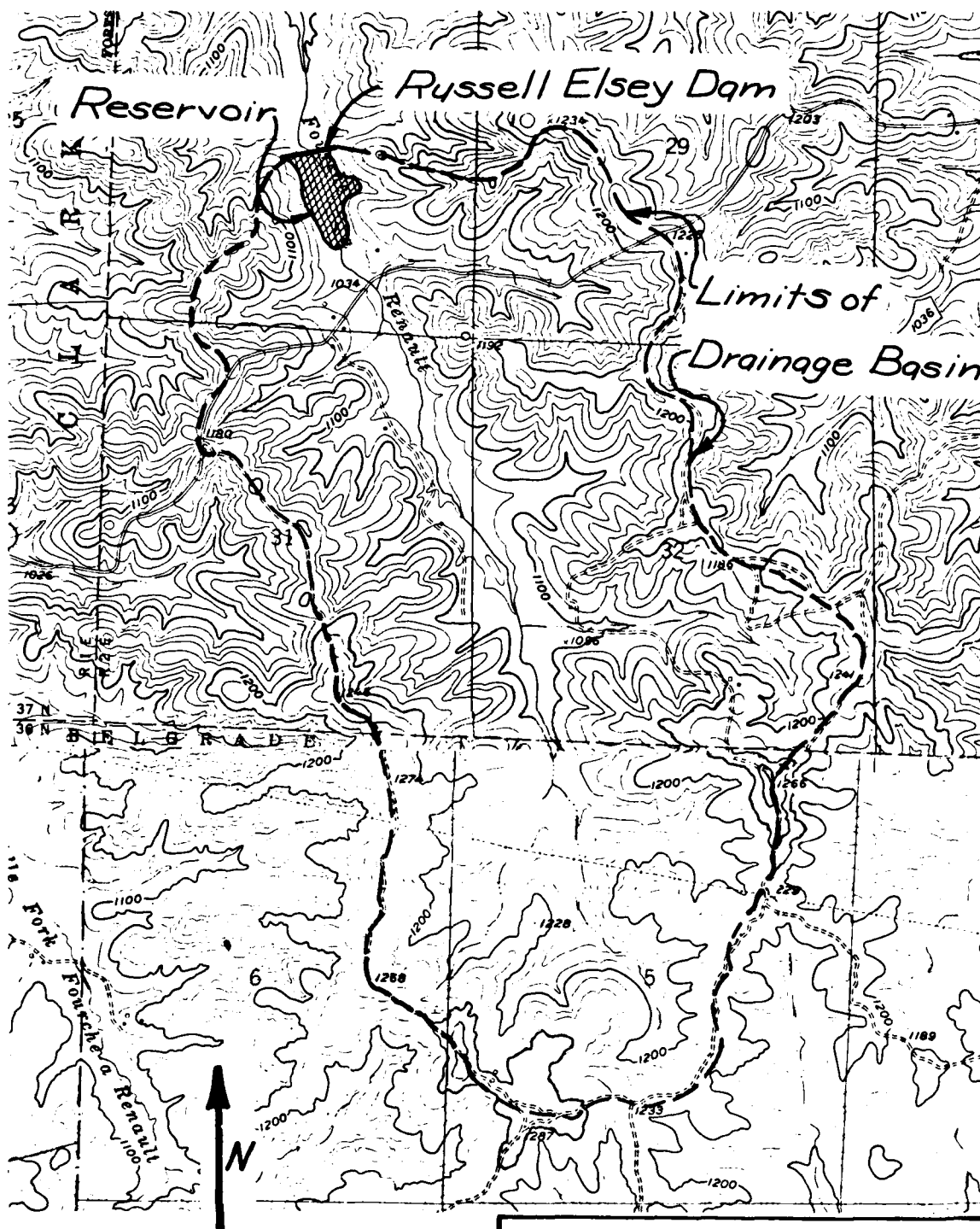


SITE LOCATION MAP

RUSSELL ELSEY DAM

MO 30102

Fig. 1



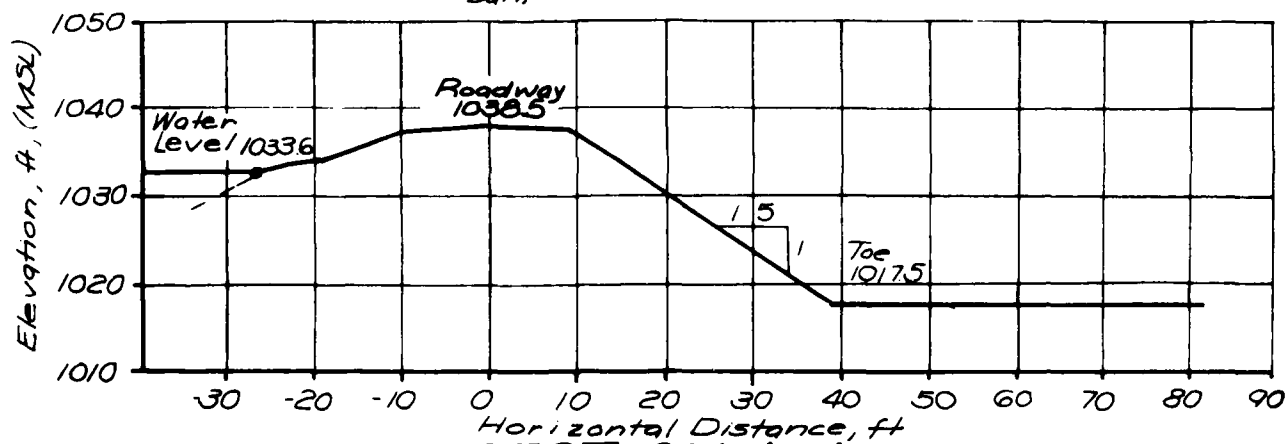
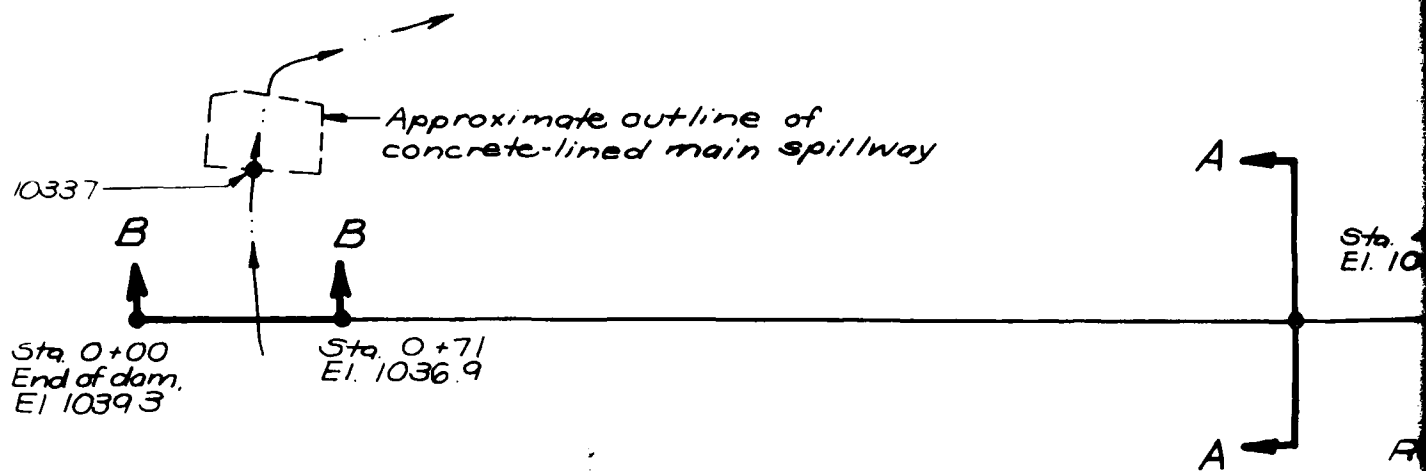
1. Topography from U.S.G.S.
Potosi and Belgrade 7½ minute
quadrangle maps

DRAINAGE BASIN AND SITE TOPOGRAPHY

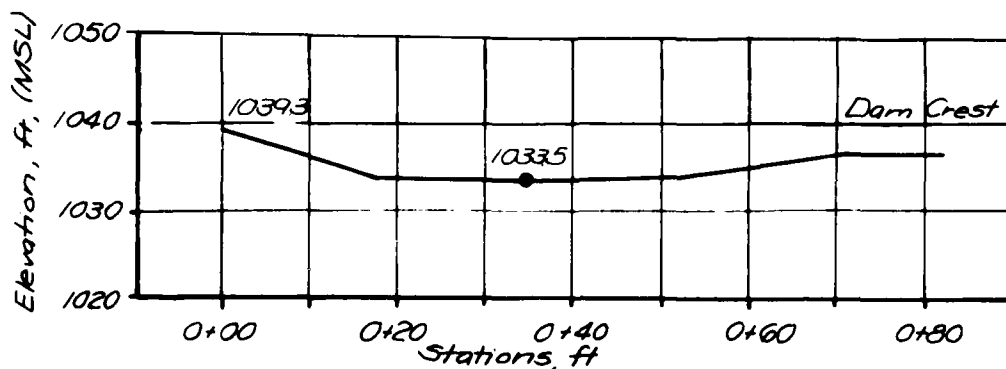
RUSSELL ELSEY DAM

MO 30102

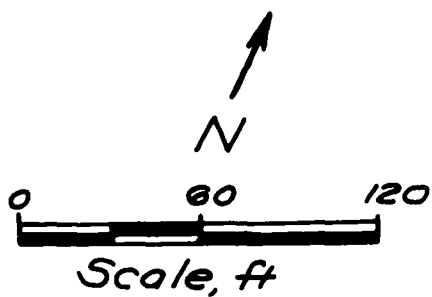
Fig. 2



SECTION A-A
Maximum Section



SECTION B-B
(Roadway, crest of dam)



Sta. 4+00
El. 1038.5

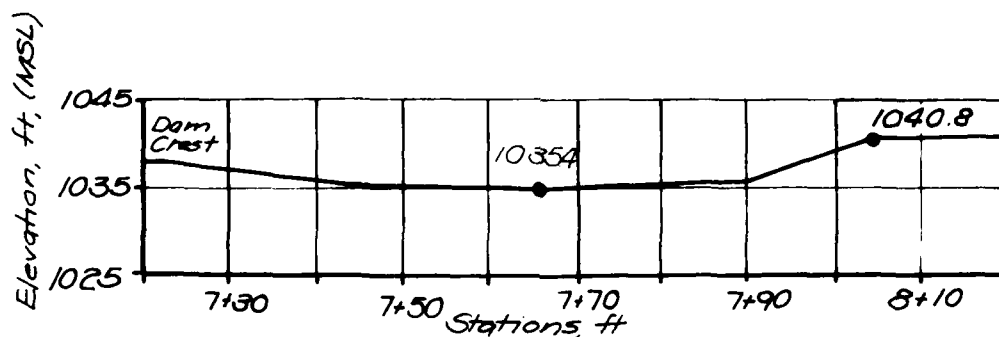
Approximate outline
of concrete-lined
auxiliary spillway

1034.8

Sta. 7+23
El. 1038.3

Sta. 8+05
End of dam
El. 1040.8

RESERVOIR



SECTION C-C
(Roadway, crest of dam)

PLAN AND SECTIONS OF DAM

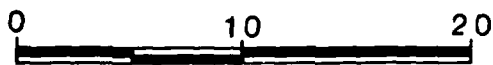
RUSSELL ELSEY DAM

MO 30102

Fig. 3



DAM
LOCATION



Scale, mile

Legend

Or	Roubidoux Formation
	Gasconade Dolomite Gunter Sandstone Member
Cep	Eminence Dolomite
	Potosi Dolomite
	Derby-Doerun Dolomite
Ceb	Davis Formation
	Bonneterre Formation Whetstone Creek Member Sullivan Siltstone Member
	Reagan Sandstone (subsurface, western Missouri)
	Lamotte Sandstone
	Diabase (dikes and sills)
	St. Francois Mountains Intrusive Suite
	St. Francois Mountains Volcanic Supergroup

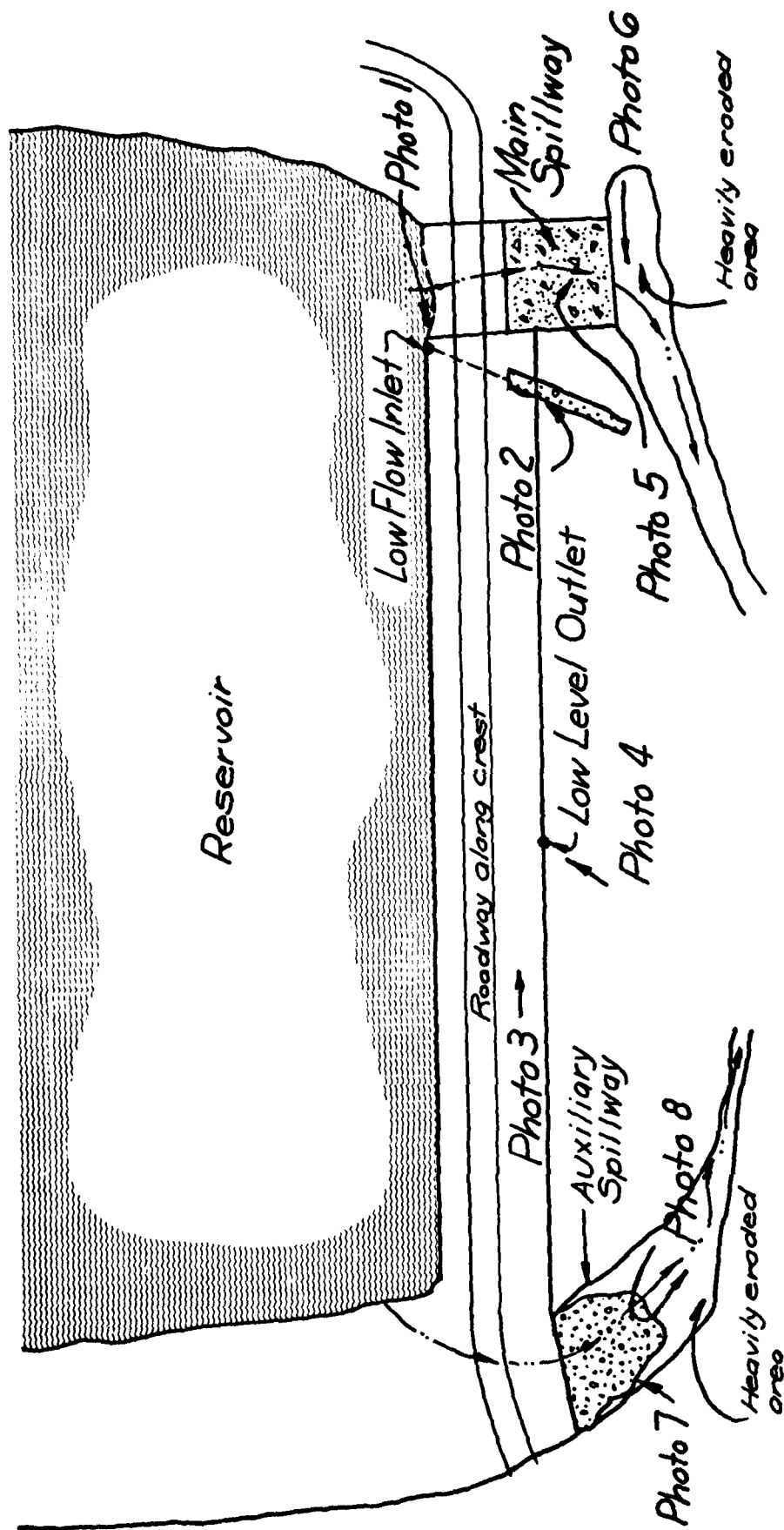
REGIONAL GEOLOGIC MAP

RUSSELL ELSEY DAM

MO 30102

Fig. 4

APPENDIX A
Photographs



0 100 200
Scale, feet



PHOTO LOCATION SKETCH

RUSSELL ELSEY DAM

MO 30102

Fig. A-1



1. View of upstream slope looking east. Note gravel wave protection. Entrance to low flow outlet at left.



2. Exit for low flow outlet and concrete-lined channel.



3. View of downstream slope looking west. Note thick grass and brush cover.



4. View of valve box for low level outlet at toe of dam. Outlet inoperable.



5. Lip of main spillway and head of discharge channel.



6. Discharge channel looking downstream. Note spillway is on rock/soil contact and erosion has taken place under concrete.



7. Upstream view of auxiliary spillway showing deterioration of concrete and erosion along edge. Note seepage at center.



8. Discharge channel for auxiliary spillway looking downstream. Note seepage.

APPENDIX B
Hydraulic/Hydrologic Data and Analyses

APPENDIX B

Hydraulic/Hydrologic Data and Analyses

B.1 Procedures

- a. General. The hydraulic/hydrologic analyses were performed using the "HEC-1, Dam Safety Version (1 Apr 80)" computer program. The inflow hydrographs were developed for various precipitation events by applying them to a synthetic unit hydrograph. The inflow hydrographs were subsequently routed through the reservoir and appurtenant structures by the modified Puls reservoir routing option.
- b. Precipitation events. The Probable Maximum Precipitation (PMP) and the 1 and 10 percent probability-of-occurrence events were used in the analyses. The total rainfall and corresponding distributions for the 1 and 10 percent probability events were provided by the St. Louis District, Corps of Engineers. The Probable Maximum Precipitation was determined from regional curves prepared by the US Weather Bureau (Hydrometeorological Report Number 33, 1956).
- c. Unit hydrograph. The Soil Conservation Services (SCS) Dimensionless Unit Hydrograph method (National Engineering Handbook, Section 4, Hydrology, 1971) was used in the analysis. This method was selected because of its simplicity, applicability to drainage areas less than 10 mi², and its easy availability within the HEC-1 computer program.

The watershed lag time was computed using the SCS "curve number method" by an empirical relationship as follows:

$$L = \frac{l^{0.8} (s+2)^{0.7}}{1900 Y^{0.5}} \quad (\text{Equation 15-4})$$

where: L = lag in hours
 l = hydraulic length of the watershed in feet
 $s = \frac{1000}{CN} - 10$ where CN = hydrologic soil curve number
 Y = average watershed land slope in percent

This empirical relationship accounts for the soil cover, average watershed slope and hydraulic length.

With the lag time thus computed, another empirical relationship is used to compute the time of concentration as follows:

$$T_c = \frac{L}{0.6} \quad (\text{Equation 15-3})$$

where: T_c = time of concentration in hours

L = lag in hours.

Subsequent to the computation of the time of concentration, the unit hydrograph duration was estimated utilizing the following relationship:

$$\Delta D = 0.133T_c \quad (\text{Equation 16-12})$$

where: ΔD = duration of unit excess rainfall
 T_c = time of concentration in hours.

The final interval was selected to provide at least three discharge ordinates prior to the peak discharge ordinate of the unit hydrograph. For this dam, a time interval of 10 minutes was used.

- d. Infiltration losses. The infiltration losses were computed by the HEC-1 computer program internally using the SCS curve number method. The curve numbers were established taking into consideration the variables of: (a) antecedent moisture condition, (b) hydrologic soil group classification, (c) degree of development, (d) vegetative cover and (e) present land usage in the watershed.

Antecedent moisture condition III (AMC III) was used for the PMF events and AMC II was used for the 1 and 10 percent probability events, in accordance with the guidelines. The remaining variables are defined in the SCS procedure and judgements in their selection were made on the basis of visual field inspection.

- e. Starting elevations. Reservoir starting water surface elevations for this dam were set as follows:

- (1) 1 and 10 percent probability events - main spillway crest elevation
- (2) Probable Maximum Storm - main spillway crest elevation

Because the low level outlet pipes are of small diameter, it was assumed they were either blocked or inoperable and did not pass any amount of the flood.

- f. Spillway Rating Curve. The basic weir equation was utilized to compute the spillway rating curve. The weir equation is as follows:

$$Q = CLH^{3/2}$$

where Q = discharge in cubic feet per second
 L = effective length of spillway in feet
 C = coefficient of discharge (2.5 to 3.1)
 H = total head over spillway in feet

Because the concrete-lined spillways are roughly trapezoidal in shape, the effective length represents a rectangular equivalent section. The effective length was calculated from field measurements. The data used in the basic weir equation are as follows:

Main spillway: $L = 36$ ft; $C = 2.6$; crest el 1033.7
 Auxiliary spillway: $L = 60$ ft; $C = 2.6$; crest el 1034.8

B.2 Pertinent Data

- a. Drainage area. 2.5 mi²
- b. Storm duration. A unit hydrograph was developed by the SCS method option of HEC-1 program. The design storm of 48 hours duration was divided into 10 minute intervals in order to develop the inflow hydrograph.
- c. Lag time. 1.8 hrs
- d. Hydrologic soil group. D
- e. SCS curve numbers.
 1. For PMF- AMC III - Curve Number 91
 2. For 10 percent probability-of-occurrence events AMC II - Curve Number 79
- f. Storage. Elevation-area data were developed by planimetering areas at various elevation contours on the USGS Potosi and Belgrade 7.5 minute quadrangle maps. The data were entered on the \$A and \$E cards so that the HEC-1 program could compute storage volumes.
- g. Outflow over dam crest. As the profile of the dam crest is irregular, flow over the crest was computed according to the "Flow Over Non-Level Dam Crest" supplement to the HEC-1 User's Manual. The crest length-elevation data and hydraulic constants were entered on the \$D, \$L, and \$V cards.
- h. Outflow capacity. The spillway rating curve was developed from the cross-section data of the spillway. The spillway outflow capacity was calculated for each spillway at various reservoir water surface elevations. The capacities of each spillway were then summed at each elevation. The results of the above were entered on the Y-4 and Y-5 cards of the HEC-1 program.
- i. Reservoir elevations. For the 50 and 100 percent of the PMF events, the starting reservoir elevation was 1033.7 ft, the spillway crest elevation. For the 10 percent probability-of-occurrence event, the starting reservoir elevation was 1033.7 ft, the spillway crest elevation.

B.3 Results

The results of the analyses as well as the input values to the HEC-1 program follow in this Appendix. Only the results summaries are included, not the intermediate output. Complete copies of the HEC-1 output are available in the project files.

 PLUMB HYDROGRAPH PACKAGE (HEC-11)
 DAM SAFETY VERSION JULY 1979
 INST MODIFICATION OF APR 80

1 A1 RUSSELL ELSER DAM NO. 30102, WASHINGTON COUNTY, MO.
2 A2 WOODWARD-CLYDE CONSULTANTS-MOUSTON, JON NO. 79CH009
3 A3 PROBABLE MAXIMUM FLOOD (PMF) ANALYSIS.

[illegible]

Input Data
Various PMF Events
Russell Elsey Dam
MO ID No. 30102

B4

FLOOD HYDROGRAPH PACKAGE (HEC-1)
WAM SAFETY VERSION JULY 1978
LAST MODIFICATION 01 APR 80

RUN DATE: 24 JUL 83
TIME: 04.46.53

RUSSELL ELSEY DAM NO. 30102, WASHINGTON COUNTY, MO.
WOODWARD-CLYDE CONSULTANTS, MOUSTON, JOB NO. 79CH009
PROBABLE MAXIMUM FLOOD (PMF) ANALYSIS.

JOB SPECIFICATION									
NO	NHR	MMIN	1DAY	1HR	IMIN	METRC	IPLT	IPRT	NSTAN
288	0	10	-0	-0	-0	-0	-0	-0	-0
JOPPR 5									
MWT LROPT TRACE									
-0 -0 -0									

MULTI-P-AM ANALYSES TO BE PERFORMED

RTIOS= .25 .30 .75 1.00
MPLAN= 1 MRTIO= 4 LRTIO= 1

SUB-AREA RUNOFF COMPUTATION

INFLOW HYDROGRAPH CALCULATION

IMYDC	1UMG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNMJ	ISAMF	LOCAL
1	2	2.50	-0.	2.50	1.00	-0.	-0	-0	-0
PRECIP DATA									
TYPE PMS 26.00 102.00 120.00 130.00 140.00 -0. R96									
R24 R49 R72 R96									

HYDROGRAPH DATA

STRF= 0. 26.00 102.00 120.00 130.00 140.00 -0. R96

LOSS DATA

-ROPT	STRKR	DLTR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CMSIL	ALSMX	RTIMP
-0	-0.	-0.	1.00	-0.	-0.	1.00	-1.00	-91.00	-0.	.02

CURVE NO = -91.00 WETNESS = -1.00 EFFECT CN = 91.00

UNIT HYDROGRAPH DATA

TC= -0. LAG= 1.80

RECESSION DATA

STRFO= -1.00 ORCSN= -.05 RTIOR= 5.00

UNIT HYDROGRAPH 26 ENJ OF PERIOD ORIGINATES. TC= -0. HOURS. LAG= 1.80 VOL= 1.00									
17.	54.	102.	163.	242.	339.	441.	531.	591.	629.
639.	637.	615.	578.	537.	490.	437.	364.	307.	263.
227.	196.	171.	150.	130.	117.	96.	86.	79.	63.

Output Summary
Various PMF Events
Russell Elsey Dam
MO ID No. 30102

B6

UNIT HYDROGRAPH 26 EN) UP PERIOD UNOINATES. FC= -0. MONTHS. LAG= 1.00 VOL= 1.00
17. 54. 102. 143. 242. 314. 441. 531. 591. 629.
619. 637. 615. 578. 537. 490. 432. 364. 307. 263.
227. 186. 171. 150. 130. 113. 94. 84. 77. 67.
25. 47. 35. 26. 23. 20. 17. 15. 15. 15.
13. 11. 10. 7. 7. 6. 4. 4. 4. 4.
3. 3. 2. 1. 1. 0. 0. 0. 0. 0.

MO.DA	HR.MM	PERIOD	RAIN	EXCS	LOSS	COMP Q	END-OF-PERIOD FLOW	HR.MM	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	1.0	1	.00	.00	.00	2.	1.02	1.0	145	.03	.03	.00	36.
1.01	2.0	2	.00	.00	.00	2.	1.02	2.0	146	.03	.03	.00	36.
1.01	3.0	3	.00	.00	.00	2.	1.02	3.0	147	.03	.03	.00	37.
1.01	4.0	4	.00	.00	.00	1.	1.02	4.0	148	.03	.03	.00	41.
1.01	5.0	5	.00	.00	.00	1.	1.02	5.0	149	.03	.03	.00	44.
1.01	6.0	6	.00	.00	.00	1.	1.02	6.0	150	.03	.03	.00	53.
1.01	7.0	7	.00	.00	.00	1.	1.02	7.0	151	.03	.03	.00	63.
1.01	8.0	8	.00	.00	.00	1.	1.02	8.0	152	.03	.03	.00	75.
1.01	9.0	9	.00	.00	.00	1.	1.02	9.0	153	.03	.03	.00	89.
1.01	10.0	10	.00	.00	.00	1.	1.02	10.0	154	.03	.03	.00	104.
1.01	11.0	11	.00	.00	.00	1.	1.02	11.0	155	.03	.03	.00	119.
1.01	12.0	12	.00	.00	.00	1.	1.02	12.0	156	.03	.03	.00	134.
1.01	13.0	13	.00	.00	.00	1.	1.02	13.0	157	.03	.03	.00	148.
1.01	14.0	14	.00	.00	.00	1.	1.02	14.0	158	.03	.03	.00	162.
1.01	15.0	15	.00	.00	.00	0.	1.02	15.0	159	.03	.03	.00	174.
1.01	16.0	16	.00	.00	.00	0.	1.02	16.0	160	.03	.03	.00	186.
1.01	17.0	17	.00	.00	.00	0.	1.02	17.0	161	.03	.03	.00	196.
1.01	18.0	18	.00	.00	.00	0.	1.02	18.0	162	.03	.03	.00	205.
1.01	19.0	19	.00	.00	.00	0.	1.02	19.0	163	.03	.03	.00	212.
1.01	20.0	20	.00	.00	.00	0.	1.02	20.0	164	.03	.03	.00	219.
1.01	21.0	21	.00	.00	.00	0.	1.02	21.0	165	.03	.03	.00	224.
1.01	22.0	22	.00	.00	.00	0.	1.02	22.0	166	.03	.03	.00	229.
1.01	23.0	23	.00	.00	.00	0.	1.02	23.0	167	.03	.03	.00	234.
1.01	24.0	24	.00	.00	.00	0.	1.02	24.0	168	.03	.03	.00	237.
1.01	25.0	25	.00	.00	.00	0.	1.02	25.0	169	.03	.03	.00	241.
1.01	26.0	26	.00	.00	.00	0.	1.02	26.0	170	.03	.03	.00	244.
1.01	27.0	27	.00	.00	.00	0.	1.02	27.0	171	.03	.03	.00	246.
1.01	28.0	28	.00	.00	.00	0.	1.02	28.0	172	.03	.03	.00	248.
1.01	29.0	29	.00	.00	.00	0.	1.02	29.0	173	.03	.03	.00	249.
1.01	30.0	30	.00	.00	.00	0.	1.02	30.0	174	.03	.03	.00	252.
1.01	31.0	31	.00	.00	.00	0.	1.02	31.0	175	.03	.03	.00	254.
1.01	32.0	32	.00	.00	.00	0.	1.02	32.0	176	.03	.03	.00	255.
1.01	33.0	33	.00	.00	.00	0.	1.02	33.0	177	.03	.03	.00	256.
1.01	34.0	34	.00	.00	.00	0.	1.02	34.0	178	.03	.03	.00	257.
1.01	35.0	35	.00	.00	.00	0.	1.02	35.0	179	.03	.03	.00	258.
1.01	36.0	36	.00	.00	.00	0.	1.02	36.0	180	.03	.03	.00	259.
1.01	37.0	37	.01	.00	.01	0.	1.02	37.0	181	.12	.12	.01	261.
1.01	38.0	38	.01	.00	.01	0.	1.02	38.0	182	.13	.12	.01	267.
1.01	39.0	39	.01	.00	.01	0.	1.02	39.0	183	.13	.12	.01	274.
1.01	40.0	40	.01	.00	.01	0.	1.02	40.0	184	.13	.12	.01	284.
1.01	41.0	41	.01	.00	.01	1.	1.02	41.0	185	.13	.13	.00	314.
1.01	42.0	42	.01	.00	.01	1.	1.02	42.0	186	.13	.13	.00	351.
1.01	43.0	43	.01	.00	.01	1.	1.02	43.0	187	.13	.13	.00	394.
1.01	44.0	44	.01	.00	.01	1.	1.02	44.0	188	.13	.13	.00	447.
1.01	45.0	45	.01	.00	.01	1.	1.02	45.0	189	.13	.13	.00	505.
1.01	46.0	46	.01	.00	.01	1.	1.02	46.0	190	.13	.13	.00	566.
1.01	47.0	47	.01	.00	.01	1.	1.02	47.0	191	.13	.13	.00	629.
1.01	48.0	48	.01	.00	.01	1.	1.02	48.0	192	.13	.13	.00	692.
1.01	49.0	49	.01	.00	.01	1.	1.02	49.0	193	.13	.13	.00	752.

Output Summary
Various PMF Events
Russell Elsey Dam
MO ID No. 30102

B7

1	4.00	48	.01	.00	.01	1.	1.02	4.00	192	.13	.13	.00	.692.
1.01	4.10	49	.01	.00	.01	1.	1.02	4.10	193	.13	.13	.00	.752.
1.01	4.20	50	.01	.00	.01	1.	1.02	4.20	194	.13	.13	.00	.810.
1.01	4.30	51	.01	.00	.01	1.	1.02	4.30	195	.13	.13	.00	.867.
1.01	4.40	52	.01	.00	.01	2.	1.02	4.40	196	.13	.13	.00	.917.
1.01	4.50	53	.01	.00	.01	2.	1.02	4.50	197	.13	.13	.00	.955.
1.01	4.60	54	.01	.00	.01	2.	1.02	4.60	198	.13	.13	.00	.992.
1.01	4.70	55	.01	.00	.01	2.	1.02	4.70	199	.13	.13	.00	1.027.
1.01	4.80	56	.01	.00	.01	3.	1.02	4.80	200	.13	.13	.00	1.050.
1.01	4.90	57	.01	.00	.01	3.	1.02	4.90	201	.13	.13	.00	1.073.
1.01	5.00	58	.01	.00	.01	4.	1.02	5.00	202	.13	.13	.00	1.094.
1.01	5.10	59	.01	.00	.01	4.	1.02	5.10	203	.13	.13	.00	1.117.
1.01	5.20	60	.01	.00	.01	5.	1.02	5.20	204	.13	.13	.00	1.128.
1.01	5.30	61	.01	.00	.01	6.	1.02	5.30	205	.13	.13	.00	1.147.
1.01	5.40	62	.01	.00	.01	7.	1.02	5.40	206	.13	.13	.00	1.154.
1.01	5.50	63	.01	.00	.01	9.	1.02	5.50	207	.13	.13	.00	1.165.
1.01	5.60	64	.01	.00	.01	10.	1.02	5.60	208	.13	.13	.00	1.174.
1.01	5.70	65	.01	.00	.01	10.	1.02	5.70	209	.13	.13	.00	1.182.
1.01	5.80	66	.01	.00	.01	11.	1.02	5.80	210	.13	.13	.00	1.190.
1.01	5.90	67	.01	.00	.01	13.	1.02	5.90	211	.13	.13	.00	1.196.
1.01	6.00	68	.01	.00	.01	14.	1.02	6.00	212	.13	.13	.00	1.207.
1.01	6.10	69	.01	.00	.01	15.	1.02	6.10	213	.13	.13	.00	1.207.
1.01	6.20	70	.01	.00	.01	16.	1.02	6.20	214	.13	.13	.00	1.211.
1.01	6.30	71	.01	.00	.01	18.	1.02	6.30	215	.13	.13	.00	1.219.
1.01	6.40	72	.01	.00	.01	19.	1.02	6.40	216	.13	.13	.00	1.218.
1.01	6.50	73	.01	.00	.01	20.	1.02	6.50	217	.44	.44	.00	1.226.
1.01	6.60	74	.03	.01	.02	22.	1.02	6.60	218	.44	.44	.00	1.246.
1.01	6.70	75	.03	.02	.02	24.	1.02	6.70	219	.44	.44	.00	1.280.
1.01	6.80	76	.03	.02	.02	27.	1.02	6.80	220	.44	.44	.00	1.332.
1.01	6.90	77	.03	.02	.02	31.	1.02	6.90	221	.44	.44	.00	1.609.
1.01	7.00	78	.03	.02	.02	36.	1.02	7.00	222	.44	.44	.00	1.516.
1.01	7.10	79	.04	.02	.07	42.	1.02	7.10	223	.53	.53	.00	1.656.
1.01	7.20	80	.04	.02	.02	50.	1.02	7.20	224	.53	.53	.00	1.826.
1.01	7.30	81	.04	.02	.02	58.	1.02	7.30	225	.53	.53	.00	2.020.
1.01	7.40	82	.04	.03	.02	58.	1.02	7.40	226	.53	.53	.00	2.230.
1.01	7.50	83	.04	.03	.01	70.	1.02	7.50	227	.53	.53	.00	2.491.
1.01	7.60	84	.04	.03	.01	90.	1.02	7.60	228	.53	.53	.00	2.679.
1.01	7.70	85	.05	.03	.02	102.	1.02	7.70	229	.66	.66	.00	2.912.
1.01	7.80	86	.05	.04	.02	115.	1.02	7.80	230	.66	.66	.00	3.187.
1.01	7.90	87	.05	.04	.01	129.	1.02	7.90	231	.66	.66	.00	3.380.
1.01	8.00	88	.05	.04	.01	143.	1.02	8.00	232	.66	.66	.00	3.610.
1.01	8.10	89	.05	.04	.01	157.	1.02	8.10	233	.66	.66	.00	3.834.
1.01	8.20	90	.05	.04	.01	171.	1.02	8.20	234	.66	.66	.00	4.049.
1.01	8.30	91	.05	.04	.01	196.	1.02	8.30	235	.60	.60	.00	4.257.
1.01	8.40	92	.08	.06	.02	202.	1.02	8.40	236	1.01	1.01	.00	4.465.
1.01	8.50	93	.14	.11	.03	219.	1.02	8.50	237	1.01	1.01	.00	4.697.
1.01	8.60	94	.35	.24	.06	241.	1.02	8.60	238	4.53	4.53	.01	5.002.
1.01	8.70	95	.10	.09	.01	270.	1.02	8.70	239	1.31	1.31	.00	5.404.
1.01	8.80	96	.04	.05	.01	304.	1.02	8.80	240	.81	.81	.00	5.872.
1.01	8.90	97	.05	.04	.01	343.	1.02	8.90	241	.62	.62	.00	6.417.
1.01	9.00	98	.05	.04	.01	398.	1.02	9.00	242	.62	.62	.00	7.040.
1.01	9.10	99	.05	.04	.01	438.	1.02	9.10	243	.62	.62	.00	7.738.
1.01	9.20	100	.05	.04	.01	489.	1.02	9.20	244	.62	.62	.00	8.417.
1.01	9.30	101	.05	.04	.01	532.	1.02	9.30	245	.62	.62	.00	9.028.
1.01	9.40	102	.05	.04	.00	566.	1.02	9.40	246	.62	.62	.00	9.452.
1.01	9.50	103	.04	.03	.00	598.	1.02	9.50	247	.49	.49	.00	9.702.
1.01	9.60	104	.04	.03	.00	600.	1.02	9.60	248	.49	.49	.00	9.797.
1.01	9.70	105	.04	.03	.00	605.	1.02	9.70	249	.49	.49	.00	9.777.
1.01	9.80	106	.04	.03	.00	601.	1.02	9.80	250	.49	.49	.00	9.635.
1.01	9.90	107	.04	.03	.00	591.	1.02	9.90	251	.49	.49	.00	9.398.
1.01	10.00	108	.04	.03	.00	577.	1.02	10.00	252	.49	.49	.00	9.101.
1.01	10.10	109	.00	.00	.00	449.	1.02	10.10	253	.49	.49	.00	8.797.

B8

1.01	17.30	105	.04	.03	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
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PEAK FLOW AND STORAGE TEND OF PERIOD SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
 FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
 AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION STATION AREA PLAN-RATIO 1 RATIO 2 RATIO 3 RATIO 4
 .25 .50 .75 1.00

HYDROGRAPH AT INFLJW 2.50 1 2449. 4898. 7347. 9797.
 6.471 1 69.3591 138.7011 208.0511 277.4111

ROUTED TO DAM 2.50 1 2416. 4890. 7339. 9787.
 6.471 1 68.4011 138.4711 207.9211 277.1411

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1..... INITIAL VALUE SPILLWAY CREST TOP OF DAM
 ELEVATION 1033.70 1033.70 1036.00
 STORAGE 274. 224. 312.
 OUTFLOW 0. 0. 1013.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.25	1038.19	1.29	352.	2416.	4.81	41.67	0.
.50	1039.02	2.12	381.	4890.	7.33	41.50	0.
.75	1039.56	2.66	400.	7339.	9.00	41.50	0.
1.00	1040.02	3.12	417.	9787.	12.67	41.50	0.

Output Summary
 Various PMF Events
 Russell Elsey Dam
 MO ID No. 30102

PEAK FLOW AND STORAGE-TEND OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
 FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
 AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION STATION AREA PLAN RATIO 1 RATIO 2 RATIO 3 RATIO 4
 RATIOS APPLIED TO FLOWS
 .09 .10 .11 .12

HYDROGRAPH AT LAKE 1 2.50 982. 380. 1078. 1176.
 6.471 24.971 27.741 30.511 33.291
 ROUTED TO DAM 1 2.50 810. 905. 998. 1093.
 6.471 22.941 25.641 28.271 30.941

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 INITIAL VALUE SPILLWAY CREST TOP OF DAM
 ELEVATION 1033.70 1033.70 1036.90
 STORAGE 224. 224. 312.
 OUTFLOW 0. 0. 1013.

RATIO OF PMF	MAXIMUM RESERVOIR W.S. ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.09	1036.55	0.	101.	810.	0.	42.00	0.
.10	1036.71	0.	306.	905.	0.	42.00	0.
.11	1036.97	0.	311.	998.	0.	42.00	0.
.12	1037.03	.13	316.	1093.	1.17	42.00	0.

Output Summary
 PMF Equivalent Capacity
 Russell Elsey Dam
 MO ID No. 30102
 B10

DATE
FILME